CHIP-SCALE ELECTRONIC COMPONENT PACKAGE

The invention described herein was made under or in the course of a contract with the U.S. Government.

1. Background of the Invention

a. Field of the Invention

This invention pertains to the packaging of electronic components and devices such as integrated circuit chips within chip-scale sized packages. More particularly this invention pertains to the packaging of acoustic wave devices and related components.

b. Description of the Prior Art

The development of very small electronic components and devices such as semi-conductor integrated circuits has given rise to the need for packages adapted for use with such small components and devices. Such packages typically must hold in place and contain such components and protect the components from harm from the environment, e.g. damage from mechanical contact, harmful electrical contact, and contact with harmful liquids and gases. The packages also usually must provide electrical connections to the components within the packages. Devices for high frequency operation must also be packaged such that the electrical connections to the device do not introduce detrimental parasitic effects.

A widely used, prior art package consists simply of the encapsulation of the integrated circuit chip, or die, within a plastic block of material, e.g. the ubiquitous rectangular solid block of plastic (dual in-line package "DIP") that has 14 or more external pins located along two sides of the block and contains a chip holding from 256 thousand to 256 million bits of random access memory. Typically, the integrated circuit chip is placed upon a lead frame and bond wires are connected between the chip and the lead frame. The chip and lead frame are then encapsulated in plastic. An alternate method of packaging is to place the die into a package having existing walls, sides and leads, connecting bond wires between the die and package lead pads and then attaching a lid to the package. Such packages, however, are unsuitable for use at microwave frequencies because the wire bond lead lengths give rise to excessive inductances and other parasitic effects that degrade device performance.

Surface acoustic wave devices and related devices such as thin film bulk-wave resonators have been developed for use with integrated circuit devices. The dice upon which these surface acoustic wave devices and resonators are fabricated typically are "chip-scale" in size, having dimensions of the order of a few millimeters in length and width and thicknesses of the order of one-quarter of a millimeter. Such chip-scale devices, however, cannot be packaged using the encapsulation technique described above, because the portion of the surface of the die that supports acoustic waves or the portion of the die that acts as an acoustic resonator must be free to deform or vibrate. If such acoustic

devices were encapsulated, the portion of the die that supported the acoustic waves or that supported acoustic deformations or vibrations would be unable to deform or vibrate and the device would then be inoperable.

In a paper titled "A New All Quartz Package for SAW Devices", in the 39th Annual Frequency Control Symposium - 1985, p. 519, Parker, Callerame and Montress disclose a package for a surface acoustic wave ("SAW") device that utilizes a quartz lid placed upon top of the substrate that contains the device, which lid is bonded to the substrate using a glass frit that provides a hermetic seal and offsets the lid from the acoustically active surface of the substrate. The electrical connections to the acoustic device, however are made via conductors located on the substrate that pass through, or under the glass frit. The quartz lid does not include electrical connections to the acoustic device. As a consequence, the packaging device described by Parker et al, is not adapted for surface mounting to a printed circuit board.

2. Summary of the Invention

The present invention is a compact package for such chip-scale acoustic wave and resonator devices, which package protects the device from damage, provides electrical connections to the device and provides a space within which the portion of the die that supports acoustic waves or acoustically deforms or vibrates

is free to acoustically deform or vibrate. The present invention utilizes the die, upon which the acoustic device is fabricated, as part of the package.

3. Brief Description of the Drawings

Figure 1 is an exploded, pictorial view of the preferred embodiment of the invention. Figures 2A, 2B and 2C are respectively top, front and bottom views of the lid portion of this invention. Figure 3A is a front view of the referred embodiment showing the lid attached to the die and figure 3B is a cross-sectional, front view of the invention.

4. Detailed Description

Referring to figure 1, a chip, or die 1 of alumina, sapphire or other suitable material, includes at its upper surface 3 an acoustic surface wave device, resonator, or other acoustic device 2. Typically a large number of acoustic devices are fabricated at one time on a single wafer of sapphire or other suitable material by etching away portions of the wafer and/or depositing successive layers of material upon the wafer and then etching away portions of the deposited materials. The wafer is then cut into individual dice, each die containing one or more acoustic devices. Each die typically may have a length and width of the order of 1 to 5 millimeters and a thickness of the order of one-quarter to one-half of a millimeter.

5

Die 1 typically will include one or more electrical signal connectors pads 4 on its upper surface 3 for the input and output of electrical signals to device 2. In the preferred embodiment, die 1 includes a bonding strip 5, which is an electrically conducting strip on the upper surface 3 of die 1 that surrounds acoustic device 2. In the preferred embodiment, bonding strip 5 operates as an electrical ground and a counterpoise for the input and output of electrical signals to and from electrical signal connector pads 4.

As depicted in figure 1, the preferred embodiment of this invention includes a lid 6 made of alumina, sapphire or other suitable material having a length and width substantially similar to the length and width of die 1 and having a thickness typically of the order of one-quarter of a millimeter. As depicted in fig. 1 and in fig. 2C, in the preferred embodiment, lid 6 includes on its lower surface 7 an electrically conducting bonding strip 8 that is similar in shape and position to bonding strip 5 on die 1.

In figure 1, lid 6 is depicted in an "exploded" position relative to die 1. As shown in fig. 3A and fig. 3B, lid 6 actually is adjacent to and bonded to die 1. Referring to figs. 3A and 3B, bonding strip 5 on die 1 and bonding strip 8 on lid 6 are joined together in the package of this invention by a thin layer of bonding material 9. In the preferred embodiment, the bonding material is a gold/tin alloy having a melting point of approximately 280 degrees. The alloy is electrically conductive and electrically connects bonding strip 5 to bonding strip 8. In

the preferred embodiment, bonding strips 5 and 8 completely surround device 2 and the bonding together of these two strips hermetically seals device 2 from the environment. The thickness of the thin layer of bonding material 9, together with the thicknesses of bonding strip 5 and bonding strip 8, provide sufficient free space 15 above surface 3 of die 1 such that the portions of device 2 that deform acoustically or vibrate do not contact lid 6 and are free to deform acoustically or to vibrate as required for the proper operation of the device.

Referring to figs. 2A, 2B, and 2C, in the preferred embodiment, lid 6 includes on its upper surface 9, an electrical conducting strip 10 and includes electrically conducting pads that form upper surface signal connector pads 11 that provide electrical connections for the input of signals to and the output of signals from the device contained within the package of this invention. Lid 6 includes on its lower surface 7 electrically conducting signal connector pads that are located under the upper surface signal connector pads 11 and that form lower surface signal connector pads 12. Lid 6 includes holes 13 passing from its upper surface 9 to its bottom surface 7. Lasers or other means may be used to fabricate the holes. Holes 13 are either lined or filled with an electrically conductive material so as to connect electrically conducting strip 10 to strip 8 and to connect electrically the upper surface signal connector pads 11 to the respective lower surface signal connector pads 12. The entire package of this invention may then be attached, lid side down, to a printed circuit by inverting the package and soldering

7

conducting strips 10 and upper input and output connectors 11 onto the printed circuit board so as to bond and connect the package physically and electrically to the printed circuit board.

Instead of soldering the entire areas of bonding strip 10 and signal connector pads 11 to the printed circuit board, a grid of high temperature solder balls may be used to attach, and electrically connect, the package to the printed circuit board.

It should be understood that although strips 10 and strips 5 and 8 have been described as conducting, in other embodiments where a ground or counterpoise for the balanced or unbalance input and output of electrical signals to and from the device is provided by other electrical connections to device 2, bonding strip 5 need not, in fact, be used as a signal ground or counterpoise, but, instead, may be used simply to provide a surface to which lid 6 is bonded. Similarly, bonding strips 8 and 10 need not be conductors, and need not be grounded.

Although in the preferred embodiment the bonding together of strip 5 and strip 8 hermetically seals the device, in instances where the device need not be hermetically sealed, strip 5 and strip 8 need not completely encompass, nor hermetically seal, the device.

Furthermore, although the preferred embodiment includes connectors for both the input and output of electrical signals

8